／PATENT SPECIFICATION

605,006

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(Under Section 6 (1) (a) of the Patents &c. (Emergency) Act, 1939 the proviso to Section 91 (4) of the Patents and Designs Acts, 1907 to 1942 became operative on Dec. 11, 1945.)

Index at acceptance:—Classes 99(i), G(4j : 11a3); and 122(iii), B11(b: c: d).

COMPLETE SPECIFICATION

Improvements in or relating to Couplings for Pipes

I, Felix Roger Malterre, of 99, rue d'Avignon, Nimes, France, a Citizen of the French Republic, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Couplings for pipes are already known which comprise internally a conical surface for wedging, between this conical surface and the tube to be held in position, a resilient metal ring which effects the rigid mechanical connection of the pipe in the coupling.

In these known couplings, however, the resilient metal ring is not held in a siutable groove in the coupling and additional members forming an abutment for the ring must be provided, whereby the manufacture and fitting of the coupling are complicated and the cost of the device is increased.

Couplings for pipes are also known, in which rubber rings deformed between the pipes to be coupled and conical surfaces of the coupling maintain these pipes in position in the coupling.

However, these rings must undergo considerable transverse deformations by means of additional members in order to be drawn into their final position. Furthermore, the connection formed is not rigid and permits relative movements of one pipe with respect to the other.

The present invention has for it object to remedy the disadvantages of these known devices, and in particular to provide a coupling by means of which a pipe can be mechanically connected in a coupling without additional members other than the resilient metal ring and by menas of a simple penetration of the pipes into the coupling, this connection nevertheless remaining perfectly rigid.

The invention concerns a coupling for pipes, which comprises a coupling member having internally a conical surface for wedging a resilient metal ring between this conical surface and the pipe to be held in position, which coupling is characterised in that the coupling member, which is formed as a socket for receiving the pipe end, comprises for receiving the resilient ring an annular groove which is, on the one hand, limited by the conical surface for wedging the ring and on the other hand by means for retaining said ring against any displacement in the opposite direction to that which produces the wedging, whereby, in particular, a smooth pipe can be mechanically maintained in a rigid fashion in the coupling member without any member other than the resilient metal ring.

In one embodiment of the invention, the coupling comprises a fluid-tight packing lodged in the coupling member, and forming a fluid-tight joint on the outer surface of the pipe to be held in position, whereby the coupling on the pipe can be rendered fluid-tight, the said pipe being furthermore held rigidly in position by the resilient ring.

Another embodiment is characterised by a fluid-tight packing combined with the socket and with the resilient fixing ring, thereby producing both an excellent fluid-tightness and the mechanical fastening of the pipe in the coupling.

According to another embodiment, the fluid-tight packing is pressed against the pipe both by its natural resiliency and by the pressure of the fluid, the fluid-tight coupling being thus obtained automatically independently of the fitter.

According to another embodiment, the fluid-tight packing and the resilient fixing ring are mounted in the socket and bear, on the one hand, on two different zones of the socket and, on the other hand on the pipe.

The invention also covers other characteristics described hereinafter and their various combinations.

Couplings according to the invention are shown, by way of example, in the accompanying drawings in which:—

Figure 1 is a partial sectional view of

a coupling according to the invention fitted at the end of the two pipes connected together;

Figure 1b is a partial sectional view of a mounted coupling;

Figure 2 is a view from the right (direction *f*) of the previous coupling;

Figure 3 is a partial sectional view of a first embodiment of a plastic resilient packing used in a coupling according to the invention;

Figure 4 is a transverse section of a resilient fixing ring fitted in a coupling according to the invention.

Figure 5 is a partial section of a third embodiment of a coupling according to the invention;

Figure 6 is a partial sectional view of a second embodiment of a plastic resilient packing used in a coupling according to the invention;

Figure 7 is a half section of a third embodiment of a packing which can be used in a coupling according to the invention;

Figure 8 is a front view of a second type of resilient fixing ring which can be used in a coupling according to the invention;

Figure 9 is a partial sectional view of a fourth embodiment of a coupling according to the invention;

Figure 10 shows by transverse sections a series of resilient fixing rings which can be used in couplings according to the invention;

Figure 11 is a partial sectional view of a first embodiment of a coupling according to the invention in which the resilient fixing ring is automatically held in contact with the socket and with the outer wall of the pipe to be coupled;

Figure 12 is an outside view in isometric perspective of a third type of resilient fixing ring which can be used in a coupling according to the invention;

Figure 13 is a transverse section of a fourth type of resilient fixing ring which can be used in a coupling according to the invention.

The coupling shown in Figure 1 includes at each of its ends in addition to the pipes 1 to be coupled, a resilient fixing ring 3. These rings and a socket 4 make up the complete coupling, the sole purpose of which is to ensure the mechanical connection of the pipes on which it is fitted.

The resilient fixing ring 3 comprises a wire of circular cross-section wound in such a manner that its two ends, which do not abut together in the free state, leave between them a space 12, (Figure 1). Initially, and taking into account the machining and manufacturing limits, its inside diameter is slightly less than the smallest outside diameter of the tube 1 and its outside diameter is larger than the smallest diameter of a conical surface 13 inside the socket 4. Said ring is generally made of a material identical to that of the two parts with which it is in contact.

The resilient ring 3 is placed in position inside the socket 4 in a groove 14 (Figures 1 and 4). Said groove 14 is limited by two conical surfaces 13 and 15 having opposite slopes of very different values.

The generatrices of the first surface 13 intersect outside the coupling and their angle of inclination is so chosen that it effects a certain and immediate wedging of the resilient ring 3 and of the pipe 1 when any movement of said pipe occurs in the direction N (Figures 1 and 4). In order to fulfil this condition, a simple examination will show the angle of inclination α must satisfy the inequality.

$$\alpha \leq \varphi_t - \varphi_m$$

φ_t being the angle of friction (that is to say the angle of which the tangent is equal in value to the co-efficient of friction) of the resilinet ring (3) on the tube (1) and

φ_m the angle of friction of the same member (3) on the conical surface (13) of the socket.

The very different state of the two surfaces 13, 15 (13 is machined whereas 15 is generally rough drawn) gives φ_t, φ_m a relatively large value, which in all cases enables the socket to be machined easily.

The conical surface 15 (Figure 4) of very steep inclination, is intended to effect the centring of the resilient ring 3 in the socket when any movement occurs in the direction M, without decreasing the resiliency of said ring.

The socket 4, the geometrical shape of which is adapted to the type of join to be effected, is generally made of a material identical to that of the pipe 1. It is provided at each joint with a centring recess 16, the purpose of which is to ensure the position of the pipe in the fitted coupling, improve the resistance to vibrations by decreasing the amplitude of same inside the coupling and serve as a stop for any movement of the tube in the direction M.

The fitting of the pipe in the complete coupling is reduced to the simplest routine. Having been cut and cleaned beforehand, if necessary, over a sufficient length, the pipe is inserted in the socket 4 until it abuts against the bottom of its housing 16 and mechanical junction is effected.

From Figures 1 and 4, the coupling

mechanism will be readily understood.

In the first place, the pipe comes into contact with the resilient ring 3 and pushes it until it encounters the conical surface 15 of the housing 14 and said ring is held against the translatory movement and expands and slides on the outer wall of the pipe 1. As it continues its movement, the pipe is stopped by the end of the centring recess 16 provided in the socket 4.

The mechanical junction of the coupling member on the pipe is obtained by means of the centring recess 16, which acts as a stop for any movement in the direction M, and by the wedging of the ring 3 and consequently of the pipe 1 in the cone 13 when any movement occurs in the direction N (Figures 1 and 4).

If it is necessary to ensure that the pipe remains absolutely stationary inside the socket, in both directions M and N, that is to say to take up the effect of the play due to the machining or manufacturing limits, a number of grooves 18 (Figure 1) provided at the end of each socket enable, while keeping the pipe abutted in the socket (direction M), the resilient ring 3 to be brought back into contact with the conical surface 13, thereby ensuring the absolute and immediate wedging of the pipe for every effort in the direction N.

Disconnecting is very simple. It suffices to move the resilient ring 3, out of contact with the conical surface 13 while pulling the pipe 1 in the direction N, which then comes out of the socket 4 without difficulty, the movement of the ring being aided by the provision of the grooves 18.

A second embodiment of the invention is shown in Figure 1b. The coupling includes at each of its ends and in addition to the pipes 1 to be coupled, a fluid-tight packing 2 and the resilient fixing ring 3. The assembly of these members and of the socket 4 forms in fact the complete coupling.

The packing (2), which is shown in a larger scale in Figure 3, is constituted by a circular ring of moulded resilient plastic material (for example, rubber), the cross section of which is **U**-shaped. This ring is therefore composed of two parallel cylindrical surfaces of different diameters joined together by a portion curved in the form of a semi-torus. The cylinder of small diameter constitutes what will be referred to as the inner skirt 6 while the cylinder of larger diameter will be referred to as the outer skirt 5.

A number of rigid rods 7, made of metal or not, placed parallel to the axis but without any interconnection, are embedded during the moulding in the inner skirt. They form a reinforcement which prevents any axial crumpling of the inner skirt 6 without decreasing the transverse resiliency thereof.

The packing is placed inside the socket 4 in a groove 8 specially provided for this purpose.

The inner surface of this groove 8 is of such form that the outer cylinder of the packing and the portion thereof curved in the form of a semi-torus, bear exactly against the said inner surface of the packing. The groove therefore follows on three sides the external form of the packing. The outer diameter of the coupling is such that, owing to the resiliency of the packing placed in position, the skirt 5 bears perfectly over its entire length against the inner surface of the groove 8. The walls 9 and 10 have no other purposes than to limit the deformations and the possible slipping of the packing 2 by the effect of a pressure which might be applied inside the fluid-tight packing and to ensure, by forming an abutment for the rods 7, a relatively fixed position of the inner skirt 6 inside the socket 4, whatever may be the axial forces to which said skirt may be subjected.

The fluid-tight packing is always mounted in such a manner that the open end of the **U** faces the direction and action of the pressure. If the effective pressure of the piped fluid is greater than zero, mounting is effected as shown in Figure 1b, that is to say the open side of the **U** is turned towards the centre of the coupling. The packing is turned towards the opposite direction in the case in which the effective pressure is less than zero.

The placing in position of the fluid-tight packing is effected by passing said packing through an orifice 11 of the socket 4. Said orifice, through which the pipe passes, is of considerably smaller diameter than the outside diameter of the packing 2 which, owing to its resilient qualities, regains its original shape when it is in its place at 8.

The inner diameter of the skirt 6 is such that, by the action of its own resilience, it bears perfectly and over its entire length against the outer wall of the pipe 1 to be coupled.

The fixing ring 3 is identical to the one already described and used in the coupling shown in Figure 1.

A number of grooves 17 provided in the wall 9 of the groove 8 (Figure 1b) enable the inside of the fluid-tight packing 2 to be placed in communication with the centring recess 16.

When ready for fitting the pipe, the coupling comprises the packing 2 and the resilient ring 3 which have been placed in position. Each element being secured, it should be noted that the whole arrange-

ment in this embodiment is in the form of a single part; the risk of loss of the component parts is practically non-existent.

As in the previous embodiment, the fitting of the tube in the coupling is reduced to the simplest routine. Having been cut and cleaned beforehand, if necessary, over a sufficient length, it is inserted in the socket 4 until it abuts against the bottom of its housing 16 and mechanical junction is effected.

By means of Figures 1b and 4 the coupling mechanism will be readily understood.

In the first place, the pipe comes into contact with the resilient ring 3 and pushes it until it encounters the conical surface 15 of the housing 14 whereby said ring is held against translatory movement and expands and slides on the outer wall of the pipe 1. As it continues its movement, the pipe encounters the inner skirt 6 of the packing 2. Owing to its internal reinforcement 7, said packing cannot crumple longitudinally and it expands and allows the pipe to be coupled to pass; said pipe will only be stopped by the bottom of the centring recess 16 provided in the socket 4. From this instant, fluid-tightness is ensured by the packing 2, the inner and outer skirts of which bear perfectly and over their entire length against the outer wall of the pipe 1 and against the corresponding concentric surface of the groove 8.

The mechanical junction of the socket on the pipe is obtained by means of the centring recess 16, which acts as a stop for any movement in the direction M, M_1, and by means of the wedging of the ring 3 and consequently of the pipe 1 in the cone 13 against any movement in the direction N, N_1 (Figures 1 and 4).

As the packing 2 is entirely enclosed, the pressure of the piped fluid which is transmitted to the inside of said packing by the grooves 17 has no other effect than that of pressing it tightly against all the walls with which it is in contact and of thereby contributing to the improvement of the fluid-tightness, which in this case is directly proportional to the pressure borne, up to the limit imposed by the maximum resistance of the packing. The risk of said packing bursting is reduced to nil.

The main advantages of the system are the following:—

Since each member only has to provide very little support during fitting, the dimensions which it must have are calculated solely from the support which they have to provide once they are placed in position.

The component elements are simple; they require only a minimum of material and of labour. Machining of the socket is reduced through the provision of the grooves 8 and 14 and of the centring recess 16, which features reduce the necessity for accuracy of manufacture. There is neither crimping nor threading in this embodiment; permissible machining limits are wide and the whole can easily be mass produced.

The placing in position of the packing 2 and of the resilient ring 3 can be done quickly and offers no difficulty. Neither of these parts can come apart of itself once it is mounted. As they are placed inside the socket 4, the risks of deterioration during transport and various manipulations are reduced to a minimum.

The resilience of the packing 2 is due not only to the particular qualities of the material used, but to its shape. Said resilience is therefore a maximum, scarcely subject to ageing and enables the pipe to undergo movements in all directions without affecting fluid-tightness.

The junction of the pipe is very simple and very quick. It does not require special tools.

The widest limits are allowed for the section of the pipe and also for its external diameter.

The quality of the joint is solely dependent on the coupling. It is independent of the skill of the fitter and skilled labour need not therefore be employed.

The work of fitting *in situ* is reduced to a minimum and the efforts required are, as nearly as possible, only those imposed by the transportation and the manipulation of pipes and couplings.

The system operates whatever be the nature of the pipe to be coupled or its external diameter. The passage cross-section of the piping is always integrally retained.

Taking apart is likewise simple and quick. The forces involved are very small so that the risks of deterioration are very reduced, whereby the possibilities of taking apart and re-assembling without spare parts are very great.

A second embodiment of the invention is shown in Figure 5. An additional part a union nut 19 fitted on the socket 21 by means of a thread 22 divides the housing of the packing 23 into two parts. A resilient washer 24, of the Grover washer type, placed between the two parts 19 and 21 prevents any untimely loosening of the union nut.

This system enables use to be made of fluid-tight packings which are slightly resilient, such as those which are shown on a large scale in Figures 6 and 7, and the placing in position of which is impossible

in a coupling of the first type (Figure 1).

The first of these packings (Figure 6) is similar to that shown in Figure 3. The only difference is that the internal reinforcement 25, which consists of one or a plurality of gauze sheets made of wire or not, is extended over almost the whole length of the two skirts 5 and 6.

The second packing (Figure 7) is formed by a metal sheet 26 which is stamped in such a manner as to have maximum transverse resilience. Two rings 27 and 28 made of plastic material (rubber, synthetic rubber, klingerit, fibre, asbestos, etc.) are placed in position on the outer skirts 29 and the inner skirts 30 and fixed on same by crimping at each end at 31 and 32.

The coupling (Figure 5) uses in addition a resilient fixing ring, shown on a larger scale in Figure 8. A number of rollers 33 is distributed along a wire 34 of circular shape, the two ends 35 of which are bent over parallel to a diameter and enable the position thereof to be fixed by penetrating into one of the grooves 18 provided either on the socket 4 (Figures 1 and 2), or on the union nut 19 (Figure 5). Each roller rotates freely on its pivot, but is fixed laterally by two widened portions 36 situated on the right and on the left and formed by partial crushing of the wire 34.

As in the previous embodiments, the disconnection of the pipe is prevented by wedging, no longer of the ring, but of the rollers in the cone 13. The only condition to be fulfilled for this purpose is that the angle of inclination α (Figure 4) of the generatrices of this conical surface is smaller than the smallest of the angles of friction of the rollers on the cone or the rollers on the pipes.

A third embodiment of the invention is shown in Figure 9. In this embodiment the housing for the packing is in three parts. Similar to the previous system, it furthermore permits a disengagement of the conduit without longitudinal displacement of this conduit. The second part of the housing of the packing, instead of being integral with the socket 21 as in the coupling shown in Figure 5, is formed by a separate part 37 which serves also for centring the pipe relatively to the union nut 19, therefore relatively to the socket 21.

Fluid-tightness between the two parts 37 and 21 is obtained by tightening the union nut and by means of an annular joint member 38 interposed between 21 and 37 and centred on this part. Rotation of 37 is prevented by the deformation of the aforesaid joint member which penetrates by the action of the tightening into two millings 39 and 40 provided on the two faces 41 and 42 of the socket and of the separate part 37.

It will be readily understood that after unscrewing and backward movement of the union nut 19, it is possible to slide the pipe on the right hand face 41 of the socket by a translatory movement perpendicular to its axis.

A coupling similar to one of these previously described, using a fixing ring of which the cross-section is not circular, but similar either to one of those given by way of example in Figure 10, or to a combination of these fixing rings, is in conformity with the present invention.

The first ring shown 43 has the two bearing surfaces on the pipe and on the cone of curved shape. The initial contact with the socket and with the external wall of the pipe to be coupled is therefore linear.

The second ring 44 has the outer surface of curved shape. It provides initially a linear contact with the corresponding conical surface of the socket. Internally, a number of notches 45 accentuate the friction on the pipe and facilitate the fastening of the ring on the outer wall of the pipe to be coupled, a bevelling 46 enables the pipe to be inserted when fitting.

The third ring 47 has the outer surface conical, contact therefore takes place with the socket along this surface. Internally a cross milling 48 enables the friction of the ring on the pipe to be greatly increased. The bevelling 46 mentioned in connection with the previous ring is again apparent.

A coupling similar to one of those previously described, but the fixing ring of which is held in contact in a permanent manner with the pipe and the conical surface of the socket, either by a system similar to those shown in Figures 11, 12 and 13, or by a combination of these systems, is in conformity with the invention.

In the first embodiment, Figure 11, the resilient fixing ring 49 is constantly urged towards the right by a helical spring 50. The actual shape of the surface of the socket forms an abutment at 51 and prevents the ring when placed in position from coming out of its housing 52.

In the second embodiment, Figure 12, the ring is similar, in its principle, to that shown in Figure 8. It is the form of its bending which ensures the permanent contact of the rollers 63 with the outer surface of the pipe and the conical surface of the socket. For this purpose, the ring being fitted in its housing on the socket, the base circumference 64 bears against

the face opposite the opening of the pipe and the wire 65 permanently tends to urge towards the right the second circumference 66 carrying the rollers 63.

A coupling similar to one of those previously described but wherein the fixing ring is made of two materials of different (from the frictional standpoint) characteristics, is in accordance with the present invention.

Figure 13 shows, by way of example, a fixing ring in which the lower part 67 is made of a material having a higher co-efficient of friction than the material of which the upper part 68 is made, so as to increase the value of the maximum angle of wedging (Figure 4). The two parts 67 and 68 can be moulded or crimped into each other.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A coupling for pipes comprising a coupling member having internally a conical surface for wedging a resilient metal ring between this conical surface and the pipe to be held in position, characterised in that the coupling member which is in the form of a socket 4 for receiving the pipe end comprises, for receiving the resilient ring 3 an annular groove 14 limited, on the one hand, by the conical surface 13 for wedging the ring and on the other hand by means 15, 50 for retaining this ring against any displacement in the direction opposite to that which produces the wedging, whereby a smooth pipe can be mechanically maintained in a rigid fashion in the coupling member 4 without any device other than the resilient metal ring 3.

2. A coupling for pipes as claimed in Claim 1, characterised by a fluid-tight packing 5 lodged in the coupling member such as the socket 4 and forming a fluid-tight joint on the outer surface of the pipe to be held in position, whereby the coupling on the pipe can be rendered fluid-tight the said pipe being rigidly held in position on the other hand by the resilient metal ring 3.

3. A coupling according to either Claim 1 or 2, characterised by the fact that the socket is provided at each end with a number of grooves for easy access to the resilient ring to enable the piping to be taken apart easily and to enable the machining and manufacturing inaccuracies of the various parts of the coupling and of the pipe to be taken up by moving the resilient ring.

4. A coupling according to any one of Claims 1 to 3, characterised by the fact that the socket is separated into two parts in order that a slightly resilient fluid-tight packing can be inserted in its housing.

5. A coupling according to any one of Claims 1 to 4, characterised by the fact that the socket is separated into three parts so that a slightly resilient fluid-tight packing can be used and the piping can be taken apart by a translatory movement perpendicular to its axis.

6. A coupling according to any of Claims 2, 4 or 5, characterised by the fact that the fluid-tight packing is pressed against the pipe both by its natural resilience and by the pressure of the fluid retained, the fluid-tight junction being thus automatically obtained independently of the fitter.

7. A coupling according to any one of Claims 1 to 6, characterised by the fact that the socket is provided with a centring recess for the pipe, said centring recess serving at the same time as an abutment for said pipe.

8. A coupling according to any one of Claims 2, 4, 5 or 6, characterised by the fact that the fluid-tight packing comprises a sheet of moulded plastic resilient material folded to provide two skirts which, one inner and the other outer, by bearing with their natural resilience against the pipe and the socket, provided a perfect fluid-tightness.

9. A coupling according to Claim 8, characterised by the fact that the inner skirt of the packing is internally reinforced in such a manner that it cannot crumple longitudinally, without this reinforcement affecting its transverse resilience.

10. A coupling according to Claim 8 or 9, characterised by the fact that the fluid-tight packing is internally reinforced over nearly the whole of its length by one or a plurality of gauze sheets, made of metal or not.

11. A coupling according to any one of Claims 2, 4, 5 or 6, characterised by the fact that the fluid-tight packing comprises a metal sheet which is stamped out and on which two fluid-tight rings made of plastic resilient material are fixed by crimping.

12. A coupling as claimed in Claim 1, characterised in that the annular groove 14 for the resilient metal ring 3 comprises as means for retaining this ring 3 a supporting surface 15 for example in the form of a very wide-angled cone, which combines with the conical wedging surface 13 to form the surface of the annular groove 14.

13. A coupling as claimed in Claim 1, wherein the resilient metal ring 3 ensur-

ing the rigid mechanical connection of the pipe in the coupling member is characterised:—

a) by a metal wire of circular section bent in circular form, the edges of which do not meet, or

b) by a metal wire of flat section bearing over a substantial surface on the outer surface of the pipe this wire being bent in circular form and the extremities thereof not meeting, or

c) by a series of rollers turning freely on a wire wound in the form of a ring, the internal diameter of the whole being substantially equal to or somewhat less than the external diameter of the pipe to be coupled.

14. A coupling according to any of the claims 1 to 13, characterised in that the superficial hardness of the resilient securing ring differs from that of the socket and of the pipe to be coupled.

15. A coupling according to any of Claims 1 to 12 and 14 characterised by the fact that the inner surface of the resilient fixing ring is arranged, either by milling or by means of notches, so as to increase the friction and facilitate its fastening on the outer wall of the pipe.

16. A coupling as claimed in Claim 1, characterised in that the means for retaining the resilient ring 3 against any displacement in the direction opposite to that which produces the wedging is consitituted by a spring 50 bearing in the annular groove 14 and maintaining the resilient ring 3 against the conical wedging surface 13.

17. A coupling according to any of Claims 1 to 12, 14, 15 and 16 characterised by the fact that the resilient ring is constructed of two materials of different characteristics from the frictional standpoint.

18. A coupling for piping substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 11th day of December, 1945.

FELIX ROGER MALTERRE,

Per: Boult, Wade, & Tennant,

111/112, Hatton Garden, London, E.C.1,

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fig. 1

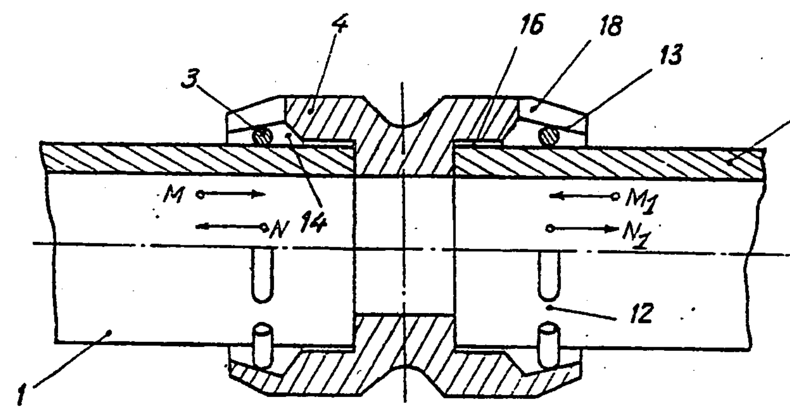
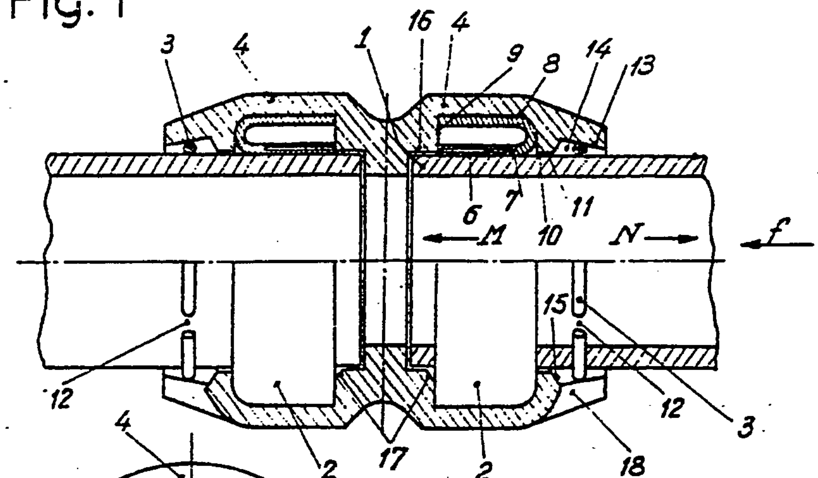


Fig. 1b



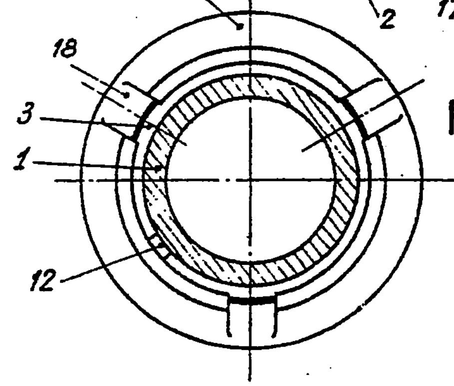


Fig. 2

Fig. 3

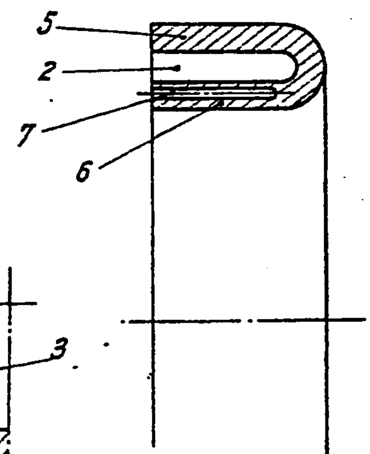
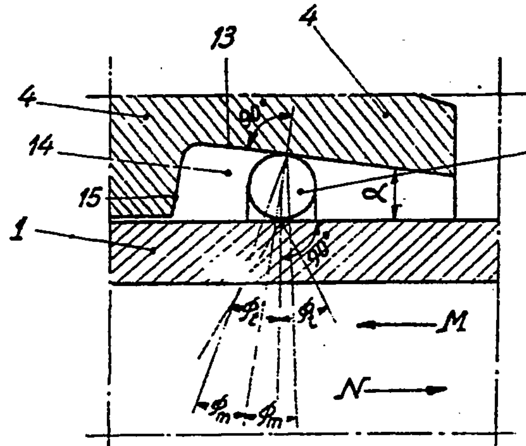


Fig. 4



[This Drawing is a reproduction of the Original on a reduced scale.]

fig. 1

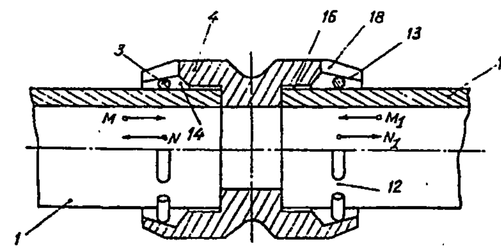
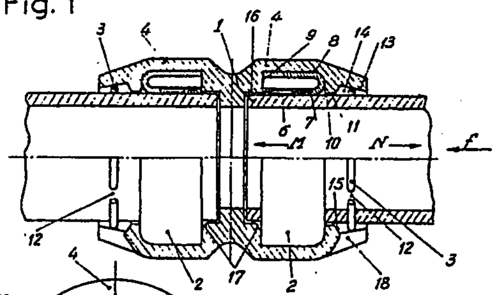


Fig. 1b



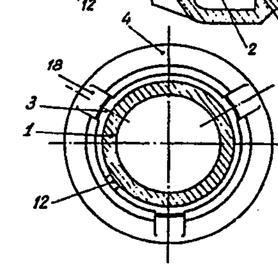


Fig. 2

Fig. 3

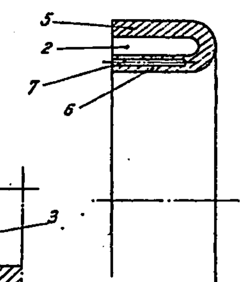
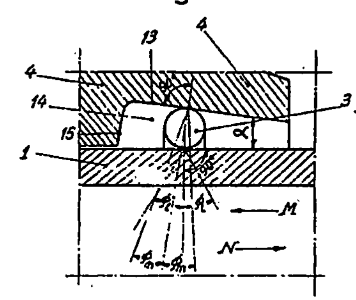


Fig. 4



H.M.S

fig.5

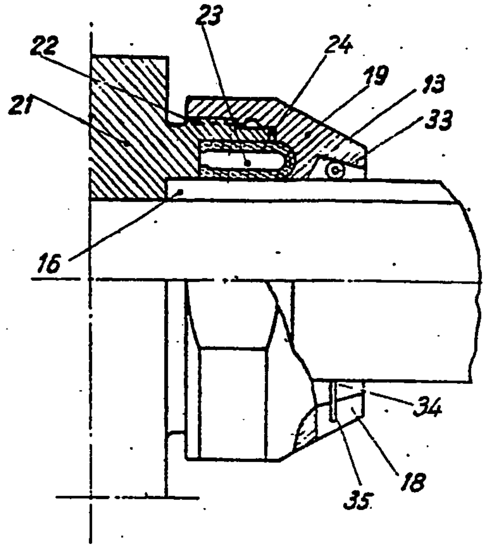


fig.6

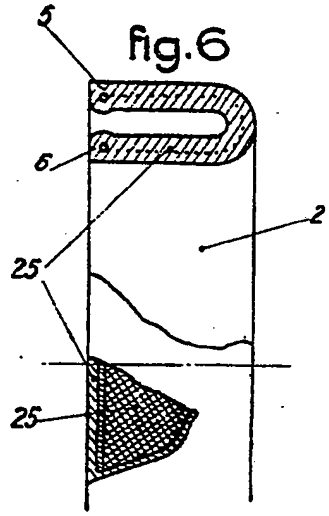


fig.7

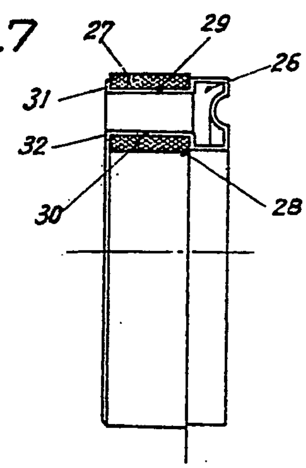


fig.8

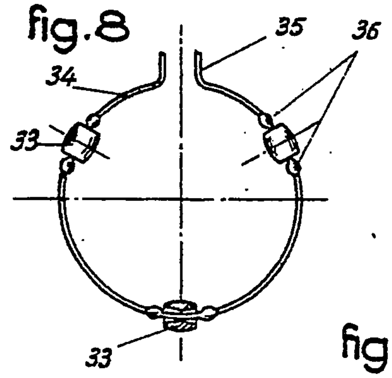
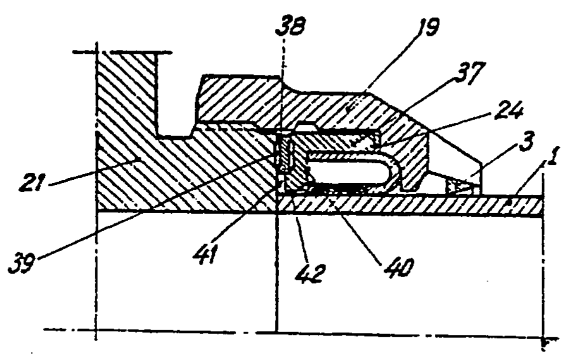


fig.9



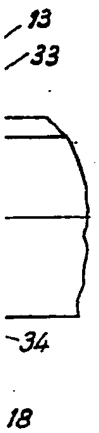
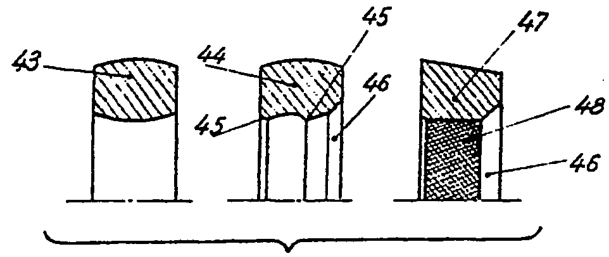


fig. 10



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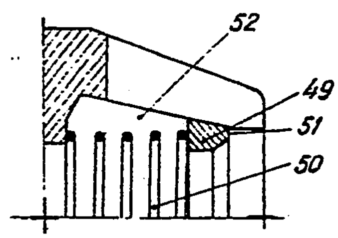

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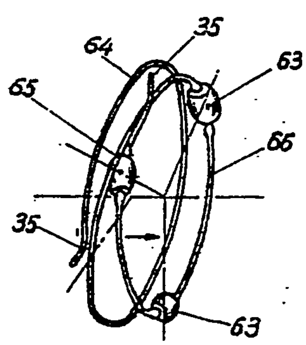

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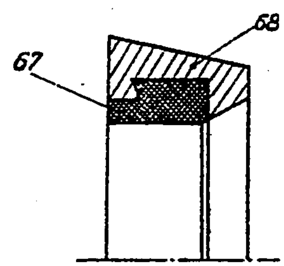
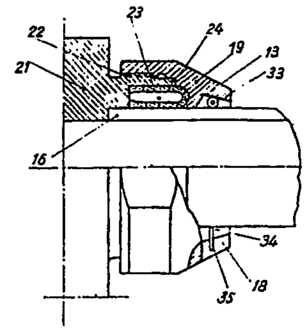


fig.5



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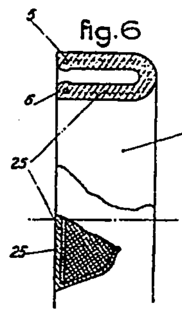


fig.7

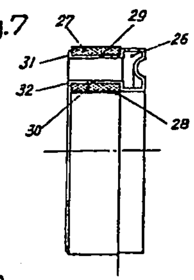


fig.8

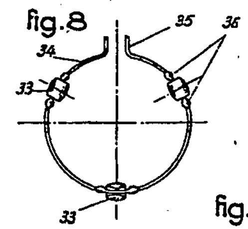


fig.9

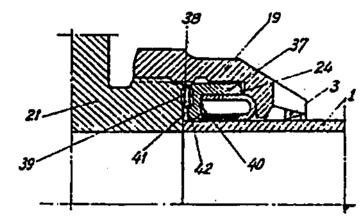


fig.10

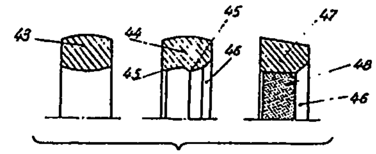
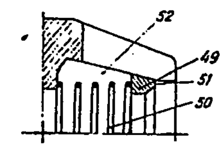


fig.11



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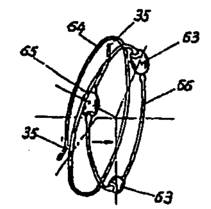
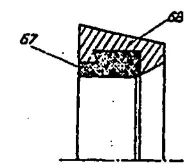


fig.13.



[This Drawing is a reproduction of the Original on a reduced scale.]

H.M.